DEVICE FOR TRANSPORTING LIQUIDS ALONG PREDETERMINED GUIDEWAYS

BACKGROUND OF THE INVENTION

The invention relates to a device for transporting liquids along predetermined guideways.

Devices for transporting liquids along predetermined guideways, for example, in the form of ducts or hoses, have been known for centuries. With the development of scientific and technological progress, these devices have been miniaturized to a greater and greater extent in certain fields of application, for example, in high-pressure fluid chromatography or pipetting systems.

Pipetting systems adapted for use with liquid samples that are mounted on planar support plates have been used for years in automated laboratory technical fields. The use of this technology permits a parallel, quick and very efficient handling of the samples. Thereby, the samples are mostly arranged in an array so that the identity of the sample can be connected to an area coordinate, and thus a precise position control of the pipetting system is possible. With the progress in dosing technology, the commercially available pipetting systems thereby follow a

continuous miniaturization, a physical limit being set, below which a reliable dosing of smallest volumes is no longer feasible.

Apart from pipetting systems, there are methods known for a simultaneous wetting of different parts of planar support plates with various liquids. These methods make use of tightly closed micro-fluid channels, formed by inserting fluid distributing structures into the support plate and sealing same by a non-structurized cover- plate deposited upon the support plate and vice versa, respectively. In WO 97/33737, for example, a structurized cover-plate is disclosed, which is brought into contact with a planer support plate. A cross-over of liquids between the channels is prevented by the tight and non-detachable connection of these plates by, for example, bonding.

The disadvantage of the tight and non-detachably connected systems lies in the fact that the pathways for the liquids are defined rigidly, and any change in distributing the liquids can only be realized by very complex three-dimensional channel guideways and additionally installed valves.

An example for the three-dimensional channel guideways is disclosed in U.S. Patent No. 5,681,484, which is used in the clinical diagnostics and the combinatorial-chemical synthesis, whereby multi-layer micro-structurized layer constructions of glass and a valve-controlled fluidics are utilized. This element of micro-fluidics has, however, the disadvantage that it cannot be used with planar

support plates, but rather requires arrangements of cavities, which are similar to micro-titer plates, for capturing liquids.

Furthermore, and apart from the above described non-detachably connected channel supporting systems formed out of plane support and cover plate, there are also detachably connected systems. An example for the flexible connection between plane support plate and structurized covering plate is U.S. Patent No. 5,429,807, in which, by the structure of the cover plate, a plurality of solved DNA synthesis reagents are wetted with chemical reactive groups line-wise on a square glass surface and, in this way, are brought to reaction. Following this reaction, the cover plate in this example is separated from the support plate, rotated by 90°, and again attached to the support so that the support is again wetted in columns with the same set of reagents. In this manner the desired product combinations are generated at the intersections of columns and lines on the support. The disadvantage of these detachably connected systems lies in the fact that the support plates and the cover plates made of rigid and non-flexible material can have fine spacings and fissures which, due to the capillary action, are filled so that a non-desired cross-over results between the channels and, thus, a mixing of the different liquids on the support plate.

A detachable joining of the support plate and the cover plate that is free of spacings and thus prevents a cross-over of the liquids requires an in-between

sealing material and an expensive mechanical construction, which renders the system unsuitable for complex reagent distribution series and automations.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a device for transporting liquids along predetermined guideways that avoids a cross-over between the different guideways due to capillary action and which obviates the remaining disadvantages of the prior art.

The object is realized by a device for transporting liquids along predetermined guideways which includes a body and an opposite body attachable thereto in juxtaposition and having a shape complementary to a corresponding shape of the body. The body is provided with elevations and recesses on a side thereof which faces the opposite body when attached thereto to thereby define capillary gaps for transporting liquids by capillary forces and capillarily inactive regions between the capillary gaps, respectively. At least one liquid supply for supplying liquid dosing to said capillary gaps is provided. Spacers are provided for spacing apart the body and the opposite body, whereby between each adjacent elevation there remains a sufficiently large recess that across the recesses a transport of liquids by capillary force is eliminated.

The essence of the invention resides in the intentional formation of capillary gaps which accomplish the transport of liquids by the capillary forces, whereby the course of the liquid transport is predetermined by the course of the capillary gaps and a cross-over of the different liquids is eliminated at a mode of operation, as specified.

In the following, the invention will be explained in more detail by virtue of various embodiments described with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of a device for transporting liquids along predetermined guideways in accordance with a first embodiment of the invention;

Fig. la is a schematic view of a possible liquid input in a device according to Fig. 1; and

Fig. 2 is a perspective schematic view of a device in accordance with a second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, an embodiment of a device for transporting liquids along predetermined guideways is depicted, and includes a body 2 and an opposite body 1 of complimentary shape to which the body can be attached, the body 2 including structures which define the guideways in conjunction with the structure of the opposite body 1. When it is specified within the context of the invention that the body 2 is complementary shaped relative to the opposite body 1, this means, for example, that when the opposite body (support plate) 1 is of overall planar configuration, as in the depicted example, the body 2 is also planar before recesses 21 are formed therein. Analogously, this is true for an alternatively shaped body 2 having an overall convex shape, in which case the opposite body 1 will be configured to have a shape complementary to the convex-shaped body 2 prior to formation therein of the recesses 21. Similarly, this is applicable to any other body 2 and opposite body 1 shaped as desired, for example, as tubes. Thereby, the body 2 is provided with elevations 22 forming capillary gaps 4 between the elevations 22 and the opposite body 1, as well as recesses 21 between adjacent elevations 22, the recesses 21 being sufficiently large that they are capillarily inactive. Furthermore, means 5, 55 for spacing apart

are provided in the device, which are shown by example with embodiments directed to planar complementary configurations in Figs. 1 and 2.

Turning now to Fig. 1a, supply means 3 are provided by which liquid can be supplied to the capillary gaps 4. Thereby, at least one liquid supply means 3, which permits dosing, can be associated to the elevations 22, and which supplies liquid via hoses 31 communicative with conduits 31a which pass through the elevations 22 of the body 2 and open to the gaps 4 serving as liquid guideways 43, as shown in the left portion of Fig. 1a, or via hose 31 which passes through the opposite body 1 in a position of the capillary gap 4, as depicted in the right portion of Fig. 1a.

The body 2 and the corresponding complementarily shaped opposite body 1 are configured as desired, in dependence on the guideways to be formed. So it is possible, although not shown in detail, that the recesses 21 and the elevations 22 are provided, for example, in a helically tapering shape into the interior wall of a second cylinder engaging a first cylinder, when a guideway is designed, for example, along the longitudinal extension of the surface of a cylinder.

In accordance with the particularly advantageous of Figs. 1 and 2, adapted for special applications described in the following, the body 2 supporting the recesses 21 and the elevations 22 takes the form, as shown in Figs. 1 and 2, of a

plane cover plate 23, to which the opposite body, which respectively takes the form of a plane support plate 11, is associated.

The spacing means 5 are, as mentioned above, is represented in Fig. 1 as being integral with, i.e., structured as a component of, the cover plate 23, or in the alternative, respectively as a component of the support plate 11 (not shown). As depicted in Fig. 1, the spacing means can be provided, for example, as regularly distributed bars, shown in lateral positions of the cover plate 23, and integral therewith, in the depicted example.

Alternatively, as shown in Fig. 2, the spacing means 5 for spacing apart the cover plate 23 and the support plate 11 of Fig. 1 can be provided instead as specially designed spacer elements 51 which are sealingly inserted between the cover plate 23 and the support plate 11. The spacer elements 51 are given a definite height x in dependence on the medium which has to be directed through the capillary gap 4.

The elevations 22 forming the capillary gaps 4 are, for example, designed as continuous bars, as shown in Figs. 1 and 2, whereby the arrangement and the route of the elevations 22 correspond to the liquid guideways 43 on the support plate 11 which are formed by the capillary gap 4 of height x and bounded on opposed sides by corresponding sides of the elevations 22 (the liquid guideways 43 being shown as bar shaped regions, indicated in Figs 1 and 2 by dark shading).

The cover plate 23 is adapted to be attached to the support plate 11 detachably, without tension in different directions. A plurality of capillary gaps 4 is provided, independently from each other on the support plate 1. The capillary gaps 4 are each provided with an inlet 41 and an outlet 42, whereby each capillary gap 4 has a special liquid supply means 3, which is shown in Fig. 1a, such that when liquid is supplied, the gaps 4 function as liquid guideways 43.

A plurality of capillary gaps 4 can be provided on the body 2 (not shown in detail in the Figures). Thereby, the capillary gaps 4 can be partially or completely connected to each other and each can have an inlet 41 and outlet 42. Consequently, the device in accordance with the invention is particularly well suited for complex reagent distribution series and automation, for example, on the basis of plane supports.

The dimensions of the capillary gap 4 are, depending on the wettability of the materials used for the body 2 and the opposite body 1 and on the state of the fluids to be guided, determined on the basis that exclusively capillary forces act upon the liquids to be transported. The dimensions for the recesses are such that they themselves are capillarily inactive.

With respect to an application of the devices in accordance with the invention, the elevations 22, running parallel to each other, have, for example, a width b in an order of size of 1.25 mm, the recesses 21 a width a of at least 1,000

μm and a depth of at least 1,500 μm. Under consideration of the properties of the materials and liquids, the generated capillary gap 4 has a length in an order of size of 200 mm. The height x of the spacing between the support plate 11 and the cover plate 23 lies, in the example, in an order of size of from 1 μm to 1,000 μm.

For forming the recesses 21 and the elevations 22, which can be arranged as desired (for example, in parallel, branching out, or meandered) structuring technologies, for example, are used as they are known from the semiconductor production (for example, etching techniques or laser ablation), wherein, for example, borofloat-glass, which has a high flatness of the surface, is used as a material for the cover plates 23.

A further possibility of providing the recesses 21 into the cover plate 23 lies, for example, in the use of diamond tools.

Another way to realize a cover plate 23 having parallel recesses 21 and elevations 22 utilizes strips, for example, fashioned out of material selectable as desired and having different dimensions which are connected with each other (for example, by bonding or melting) in such manner that an arrangement of recesses 21 and elevations 22, for example, in analogy to Fig. 1, is obtained.

The spacing means 5, 51 are connected, for example, by bonding or melting to the cover plate 23 and the support plate 11, respectively, or they are laid in loosely between the plates 11 and 23. Alternatively, the spacing means 5

can be directly worked out of the material of the support plate11 or the cover plate 23 by the structurizing technologies used.

The different liquids, when using the device in accordance with the invention, are transported by the liquid supply means 3, shown in Fig. 1a, to the respective inlet 41 of the elevations 22, whereby due to the effective capillary forces the respective capillary gap 4 is filled (shown as dark shaded regions). The liquid supply is then accomplished either through the liquid supply means 3, shown in the left part of the Fig. 1a, via the cover plate 23 or, where appropriate, through the liquid supply means 3, shown in the right part of the Fig. 1a, that can be provided in the support plate 11. The discharge of the liquid is accomplished via the outlet 42.

For example, plane, planar or substrate plates provided with recesses are used as support plates 11, whereby these recesses can be, for example, cavities provided with micro-beads.

Advantageously, micro-titer plates or nano-titer plates as well as bio-chips in the form of plane, planar substance libraries can, for example, be used as support plates 11.

In an application of the device, for example, a square support plate 11 of n lines can be wetted with n different liquids by a square cover plate 23 provided with n+l recesses 21 which are parallel to each other. After removal of the cover

plate 23, the removal of the liquids from the support plate 11, the turning of the cover plate 23 about 90° and establishing again the spaced apart connection between the cover plate 23 and the support plate 11, the wetting with n-columns of n different liquids is feasible, so that an n-n pattern of the intersections of lines and columns results. Due to the application of the device described in the example, an orthogonal liquid distribution as, for example, required in the combinatorial chemistry for the synthesis of substance libraries can be accomplished in a particularly easy manner.